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BIO-PROTECTION OF GLU-LAMS

Glu-lams bio-protection technology is presented here. Analysis of bio-damaging factors of glu-lams is done. Basic requirements to the modern antiseptics are given. Influence determination researches of bio-protection means and treatment mode for ultimate stress on glued connection were conducted. The presented technique permits to achieve a high level of glu-lams bio-protection without reducing the strength factors of glued connections.

Introduction. Year after year glu-lams become more popular and are used more often in civil and industrial construction. The reason for that is the material light weight and durability. Thanks to modern technologies it is possible to manufacture practically any glued bar structures. These structures give a possibility to implement the most difficult engineering designs. The material is light but is capable to carry considerable loads. In addition to usual glu-lams they produce bent structures with bending of 6 m and more. Processing ease is also an important advantage of this material. Considerable in relation to metal fire immunity is also important. Structures preserve their bearing properties during longer period of time in the elevated temperatures conditions. Ability of wood to withstand influence of salts and other chemical substances favourably distinguishes this material from concrete and metal which are exposed to strong corrosion while contacting chemical substances. A certain advantage of the glu-lams is ecological compatibility and high aesthetic qualities. Now glu-lams are used in building sport and trade facilities, maneges, garrets, bridges, etc. This material is very popular in low-rise house-building. Glued building bars floor beams and roof timber are used in it. Any building where glued timber was used is unique.

Along with the presented advantages the glu-lams have also an essential disadvantage – they have to be protected against biological factors [1].

The most dangerous destroyers of glu-lams are cellar fungi. The most dangerous and widespread cellar fungi are: real cellar fungus (Merulius lacrymans), white cellar fungus (Poria Vaporaria), scarious cellar fungus (Coniophora Puteana), mine fungus (Paxillus acheruntius). Wood is considerably damaged by different insects: beetles (capricorn beetles, buprestid beetles, bark beetles, snout beetles, true powderpost beetles, furniture beetles), horntail sawflies, termites, ants and others. It is necessary to note the wood worm (Anobium punctatum) as especially harmful. It affects both hard and soft wood species usually damaging sapwood. Goat-chafer black cellar (Hylotrupes bajulus) is considered to be the most dangerous pest for building wood in Belarus. It attacks sapwood of dry soft wood.

Geography of production distribution of the Belarus house-building factories extends constantly. The countries of southern region start to get into it, for example Venezuela. It is necessary to consider peculiarities of their subsequent service while manufacturing building structures. Among such peculiarities it is necessary to single out the danger of affection with the most terrible wood destroyers – termites as the southern countries territories are within the regions of their spreading (Fig. 1).

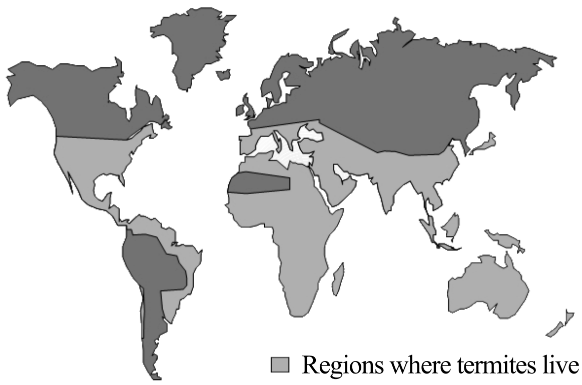

Fig. 1. Regions where termites live

One of the most effective wood protection modes from bio-destructions is autoclave treatment. So, within the limits of the European Union countries 18 million m^3 of wood [2] is impregnated. Distribution of impregnated wood on operation classes is given in Table 1.

Table 1

Volumes of wood impregnation in Europe

Wood operation class	Volumes of wood, millions of m^3
HC 1/2	10.3
HC 3	6.6
HC 4	1.8

However for application of the given protection mode careful influence studying of antiseptics and impregnation mode on durability of glued connections of glu-lams to provide the demanded reliability of building structures is required.

Goal of this work is a possibility study of the autoclave impregnation of glu-lams to give them bio- and fireproof properties.

Main part. Bio-protection of glu-lams with the help of autoclave impregnation can be done in two ways. The first way consists in preliminary impregnation of lamels and their subsequent gluing. The given technology permits to achieve a high level of wood bio-protection but is very labour-consuming. The second way is impregnation of the prefabricated glu-lams. It is a fast and reliable way but it requires the autoclaves dimensions corresponding to dimensions of wooden elements. Such equipment is possessed in Belarus by the open society "Borisov sleeper factory". The second way of bio-protection is used for researches. It is easily implemented and is notable for a higher ecological compatibility of manufacture as it does not require machining of the impregnated wood.

It is possible to name a number of requirements to the protective means used for wood impregnation. They should correspond to STATE STANDARD 30495 and 30704, i.e. the antiseptics should be high-performance in relation to mouldy, colouring fungi, to wood-damaging fungi and simultaneously have low toxicity for warm-blooded, it should readily penetrate into wood, have low corrosion activity, not reduce physical-mechanical wood characteristics on more than 20%, provide long-term protection depending on the class of service conditions. Besides fungicidal properties these protective means should also have insecticidal properties. In case of export of the impregnated wood to the European Union countries antiseptics should correspond to requirements in use there.

STATE STANDARD 20022.0 defines the list of antiseptics for wood impregnation. They are: resin oil, shale oil, NM-M, CHM, CHMF-BF, CHMFC, Senezh, Akvabor, CHMF, CHMBB, CHMK, BB. The offered antiseptics are rather effective and checked up by time, however they do not correspond to the modern ecological requirements and have the fungi influence mechanism of the previous generation. The instruction of Euro commission accepted in 2003, limits wood usage treated by SSA-salts.

Now the market in the field of wood protection offers a wide variety of protective means. Absence of authentic data about antiseptics durability and laboratory techniques to define the service life of the impregnated wood complicates definition of the application field and the required absorption of impregnating compounds. Not only foreign but also modern domestic antiseptics do not meet the classification of STATE STANDARD 20022.0. Difficulties of operating standards usage are also coupled with considerable discrepancy to the European normative documents.

Water-soluble and oil antiseptics were used for impregnation of glu-lams. As water-soluble it is offered to use modern protective means with the alkaline environment on the basis of copper salts and organic biocides. Suitable compounds are copper sulphate, acetate, hydroxide, oxide, borate, fluoride, hydroxide-carbonate. Metal-complexes of salts provide successful struggle against fungi illnesses and, that is especially important, against rot of wood. The majority of modern antiseptics contain such active biocides as azoles (as a rule, they are derivatives of imidazoles and triazoles). Antifungal action of azoles is caused by membrane integrity disruption of the fungus cell. Azoles disturb synthesis of ergosterol – the basic structural component of fungi cell membrane. To prevent development of fungi resistance and of technical vermin to antiseptics modern bio-protective means possess at once several mechanisms of influence which frequently show a synergetic effect.

Tanalith E, Bochemit Forte, Korasit, Bio-Wood 0108 [3] are protective means of this type. Researches were carried out using the antiseptic Tanalith E 3492.

As oil protective means they used impregnating compound SMPS made in Belarus.

Researches were carried out on the samples from wooden glued bar pressed with the usage of melamine urea formaldehyde adhesive "Kaskomin 1242" and hardener 2,542 manufactured by the company "Akzo Nobel". Workpieces for samples with dimensions of 50×50×180 were cut out from the bar face parts with the thickness of dropout not less than 50 mm (Fig. 2).

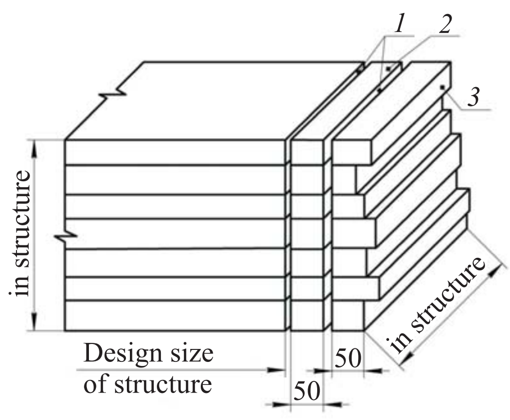

Fig. 2. Samples manufacturing:
1 – kerfs; *2* – workpiece for samples;
3 – dropout

Workpieces were sawn into samples in the form of a rectangular prism with the section of ((50×50) ±0.5) mm and height h, equal to elements section height (Fig. 3).

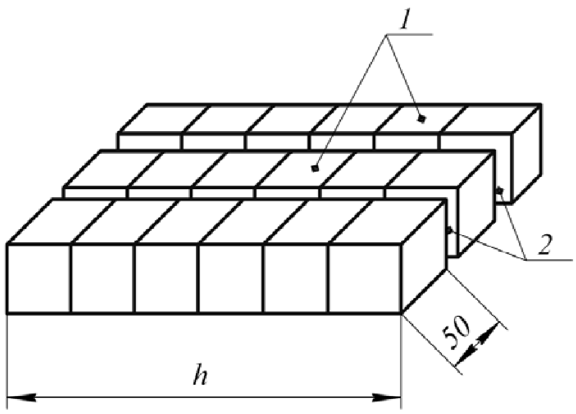

Fig. 3. Samples manufacturing:
1 – samples; *2* – kerfs

Then one part of the received samples was exposed to autoclave impregnation under pressure of 1.1 MPa by water-soluble antiseptic Tanalith E 3492, the other – by oil protective means SMPS. Impregnation process kinetics is given in Fig. 4.

Absorption for the bio-protective solution with concentration of Tanalith E 3492 was 4.5% – 143 kg/m^3; for antiseptic SMPS – 96 kg/m^3. The given absorption exceeds the required one for wood operation in especially severe conditions more than 1.2 times [4].

Having reached humidity of 12% samples were tested according to the STATE STANDARD 25884 for layer-by-layer chipping of glued connections. The device for carrying out the tests is given in Fig. 5.

The chipping breaking point of the glued connection τ was defined with the accuracy up to 0.1 MPa according to the formula:

$$\tau = \frac{P}{F}, \qquad (1)$$

where P – ultimate breaking load, H; F – cross-sectional area, m^2.

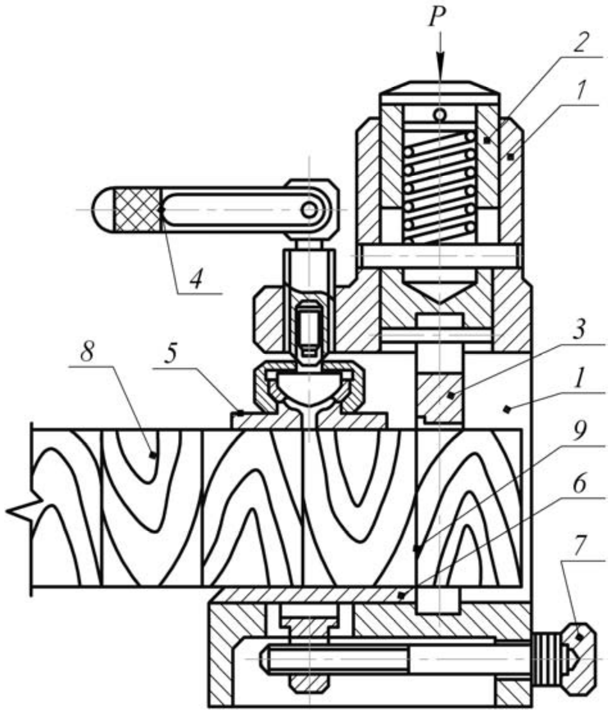

Fig. 5. Tests device:
1 – body; *2* – punch; *3* – punch knife; *4* – handle;
5 – clamping support; *6* – mobile pressure pad;
7 – detent screw; *8* – sample; *9* – glued connection

From the tests results given in Table 2, it is clear that autoclave impregnation of glu-lams under pressure is not more than 1.2 MPa by water-soluble protective means Tanalith E 3492 and oil antiseptic SPMS for operation class HC 4 slightly reduces the breaking point of the glued connection.

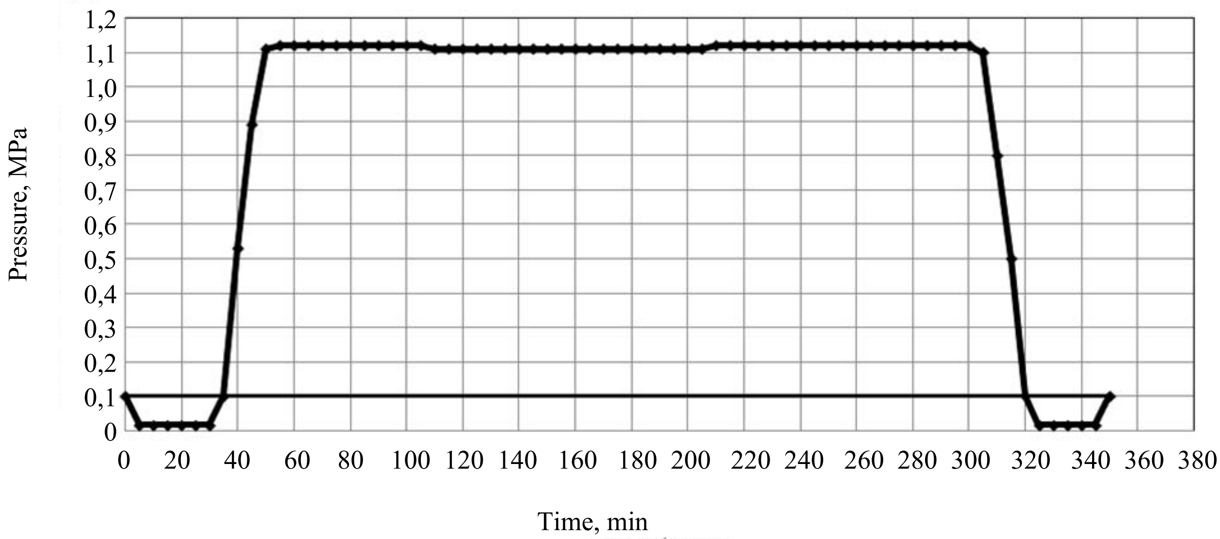

Fig. 4. Impregnation diagram of samples under pressure

Table 2

Research results of breaking point on the glue line of the impregnated wood

Impregnation type	Sample dropout area F, m^2	Ultimate braking load P, kN	Breaking point of the glued connection τ, MPa	Breaking point of the glued connection with respect to unimpregnated wood, %	Damage pattern of the glued connection
Wood samples at layer-by-layer chipping					
Tanalith E 3492	0.0025	20.4	8.16	96.2	cohesive
SPMS	0.0025	20.7	8.28	97.6	cohesive
Check unimpregnated samples	0.0025	21.2	8.5	–	cohesive

Conclusion. Qualitative bio-protection of glulams can be obtained by the autoclave impregnation by modern bio-protective means, such as BioWood 0107, Tanalith E 3492, SPMS.

The offered way of bio-protection provides durability of glued connections according to the requirements of STANDARD 20850-84.

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